objected to. Claims 2 and 8 have been amended to delete these terms.

Claims 1-5 and 7-10 were also rejected under 35 U.S.C. §103 (a) as being unpatentable over Syverson, U.S. Pat. No. 5,918,728 in view of Muller, U.S. Pat. No. 4,730,136.

In response claim 1 has been canceled without prejudice and claims 2-10 have been made to depend directly or indirectly on claim 2.

New claims 11 and 12 have been added to further define the motor sensor and to claim a sensor in combination with a control for commutating current in the stator coils, which is distinctively different from the control in Syverson.

Claim 2 claims the feature wherein a cylindrical metal housing forms a part of the rotor for receiving the segments of permanent magnetic material and for supporting the shaft and the stator coils in a motor assembly; and wherein said motor assembly is disposed inside of and secured to said roller.

In Syverson the cylindrical metal housing 40 is not present. The permanent magnet material of the stator is assembled directly into a roller. Notice that in claim 3 of the present invention, it is <u>the housing</u> that is press fit into the roller. The housing 40 is not present in Syverson.

The rollers of conveyor systems are subject to stresses and deflection in use, and in Syverson such stresses would be transmitted directly to the stator and permanent magnet pieces.

In the present invention, the embodiment of Fig. 2 may also be constructed so that the roller 14 extends beyond the bearing 42 as shown in Fig. 3 for roller 14 and bearing 47. In this case, the housing 40 in Fig. 2 adds to the stiffness of the roller 14 near the parts 10, 16, 18 of the motor. The bearings 42, 47 maintains the clearance in the region of the motor, while deflection may occur in any portion of the roller extending beyond the bearing 42, 47.

The additional housing 40 in the present invention allows easier assembly and makes the assembly less susceptible to the above-mentioned stresses.

Claim 4 recites the feature wherein said housing and said plurality of stator coils extends only part way in an elongated direction of said roller (see Fig. 3). In the Office action, it was said that is obvious to make the motor assembly smaller than the full roller as merely being a change of size for the application. It is submitted that the reason that the motor is made shorter is to relieve it from the stresses of deflecting the roller, and this is not suggested by the prior art or from information available to one of ordinary skill in the art.

Claim 8 recites the added feature of a motor wound to produce a ratio of stator voltage to speed of at least 10 RMS volts per 1000 RPM for an applied stator voltage of 24 RMS volts per phase. Syverson does not discloses any voltage-to-speed ratio of the motor. This feature of claim 8 determines the torque-to-current ratio. A high voltage-to-speed ratio reduces the motor current required to produce a given amount of torque. Minimizing current improves efficiency and lowers the cost of the controller. Since these rollers typically operate below 1200 rpm, the voltage-to-speed ratio should be at least 10Vrms per 1000 rpm when used in a 24V system.

Claim 9 specifies the feature wherein each stator coil encircles a single stator tooth. Syverson does not specify a winding pattern. Syverson further states that the number of poles is sixteen, and the number of slots is twelve. While this reduces the number of options in this particular case, Syverson does not specifically disclose concentrated coils wound around a single tooth. In particular, it does not explicitly or implicitly state that any particular coil span should be used.

In the invention, it is stated in the Detailed Description as well as in claim 9 that the windings are concentrated around a single tooth (regardless of the number

of slots and poles). This has certain advantages: (a) manufacturing is easier than winding patterns where coils span multiple teeth; (b) end turn management is simplified; (c) a minimal amount of wire is used; and (d) power density and efficiency is maximized. Operating at high efficiency is especially important in this application because heat removal is difficult, since the motor is enclosed in a metal tube.

Syverson states that the motor is controlled by a "variable frequency controller." Using a controller like the one described in Syverson, which applies three phase 24 volts to the motor and varies speed by changing the frequency, is not deemed to be as effective as the control provided by the present invention. With this method, the torque angle is dependent on speed and load, and generally is not near the optimal 90 degrees. As a result, motor current is excessive, efficiency is poor, and the risk of overheating is increased.

In the invention, as claimed in new claim 12, it is specified that current in the stator coils is commutated. This method of control requires information about the position of the rotor. There are significant benefits in using commutation control rather than the variable frequency control in that it improves starting, acceleration, braking, and peak output power. These are desirable features of a conveyer system. In addition, the motor operates at higher efficiency, resulting not only in lower surface temperature of the roller, but also increasing reliability and permitting the use of smaller, less expensive motors and controllers.

Because Syverson uses variable frequency control, it does not disclose a motor having a position sensor. The purpose of the position sensor in the invention is not as the examiner states, "to position the rotor in a position favorable to starting." Its purpose is to provide continuous position feedback to the controller for the purpose of commutating the windings.

Effective control of a brushless dc motor requires knowledge of the rotor position with respect to the windings.

This information can be measured directly, using a position sensor, or estimated from measurements of other quantities such as terminal voltages. Estimating position at zero speed and low speed is difficult, requiring sophisticated controllers and special motor designs. Therefore, in applications where the operating range includes speeds of less than ten percent, and full speed or starting under load is required, a method of control using a position sensor is advantageous.

In a motorized roller that is directly driven, the free running drag is considerably lower compared to one in which a gearbox is used. The lack of drag necessitates the incorporation of some type of active braking feature into the controller. A position sensor simplifies this, in that it can be used to determine the time at which the braking function can be disengaged.

The invention of claim 11 provides a motor using a position sensor having three Hall effect devices and shows a method of incorporating them by mounting them on a circuit board so that they are positioned inside the main motor and activated by its flux.

The motor described in the Muller patent is a single phase motor, having different starting and position detection requirements than the three-phase motor described in the invention.

The discussion of the Gale patent in the Office Action is confusing. It seems to indicate that the gaps between adjacent magnetized segments are significant, and that this gap is intended to form a part of the magnetic circuit. In fact, the only mention of such gaps is in the description of the rotor, and the point here is that the gaps are narrow, that is, they account for only a small portion of the magnet surface. There is no mention of these gaps in the claims.

In the present invention, the roller provides a low reluctance magnetic path, whereas air gaps provide a high

reluctance magnetic path, which requires extra energy for operation.

In summary, the invention of the claims provides:

1) a modular design, which is not affected by flexing of the roller under load;

2) a more rugged design, having improved manufacturability and fewer components;

3) a winding pattern in which windings are concentrated around a single tooth, resulting in high power density and efficiency;

4) a position sensor which provides feedback to a commutation controller that allows better control and efficiency; and

5) a method of motor control incorporating the position sensor.

Conclusion

In view of the Amendment and Remarks, reconsideration of the application is respectfully requested. After the Amendment, claims 2-12 are still pending, and a Notice of Allowance for these claims is earnestly solicited.

Respectfully submitted,

By: [signature]

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Version of Amended Claims with Changes Marked

2. (Amended) A motor for driving a cylindrical roller that rotates around a stationary shaft, the motor comprising:

a cylindrical rotor disposed inside of and mounted to rotate with said cylindrical roller around said stationary shaft;

wherein said rotor is formed of a plurality of longitudinal segments of permanent magnetic material, wherein said segments alternate orientation of north-south magnetic polarity in a radial direction to produce flux in flux path loops connecting pairs of the longitudinal segments;

a plurality of stator coils mounted on said shaft for receiving current from an external power supply that commutates current in said stator coils;

wherein said motor is a brushless d.c. motor;

[2. The motor of claim 1, further characterized by:] further comprising a cylindrical metal housing [which forms] forming a part of the rotor for receiving the segments of permanent magnetic material and for supporting the shaft and the stator coils in a motor assembly; and

[further characterized in that] wherein said motor assembly is disposed inside of and secured to said roller.

3. (Amended) The motor of claim 2, [further characterized in that] wherein said motor assembly is secured to said roller at least in part by a force fit of the cylindrical metal housing inside said roller.

4. (Amended) The motor of claim [1,] 2 or 3, [further characterized in that] wherein said [rotor] housing and said plurality of stator coils extends only part way in an elongated direction of said roller.

5. (Amended) The motor of claim [1,] 2 or 3, [further characterized in that] wherein said rotor and said plurality

of stator coils extend substantially an entire length of said roller.

6. (Amended) The motor of claim [1 or] 2, [further characterized in that] wherein said plurality of poles includes at least six poles formed in said cylindrical member as longitudinal segments with segments of alternating north-south magnetic polarity with said roller providing a magnetic path between segments.

7. (Amended) The motor of claim [1,] 2 or 3, [further characterized in that] wherein said rotor is connected to directly drive said roller without the use of a reduction gear assembly.

8. (Amended) The motor of claim [1 or] 2, [further characterized in that] wherein the stator coils are formed of a [sufficient] number of turns [of a sufficiently narrow] and a gauge of wire selected to produce a ratio of stator voltage to speed of at least 10 RMS volts per 1000 RPM for an applied stator voltage of 24 RMS volts per phase.

9. (Amended) The motor of claim 8, wherein the stator has a plurality of teeth, and [further characterized in that] wherein each stator coil encircles a single stator tooth.

10. (Amended) The motor of claim [1 or] 2, [further characterized in that] further comprising [the sensor means is] a sensor for detecting a rotational position of the rotor.